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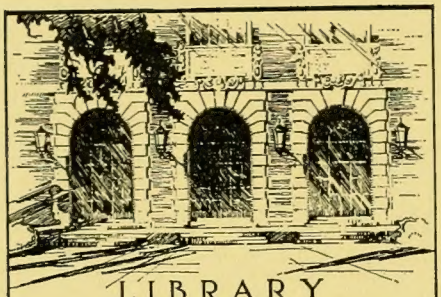
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NATURAL HISTORY
SURVEY.

STATE OF ILLINOIS
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DEPARTMENT OF REGISTRATION AND EDUCATION
John J. Hallihan, Director

LAKE MANAGEMENT REPORTS

3. Lincoln Lakes near Lincoln, Illinois

David H. Thompson

and

George W. Bennett

Printed by Authority of the State of Illinois

NATURAL HISTORY SURVEY
Theodore H. Frison, Chief

Biological Notes No. 11 Urbana, Illinois August, 1939

FIG. 1.--Bathing beach at Lincoln Lakes built by the Lincoln Sand and Gravel Company. (Photo by Herbert Georg Studio.)

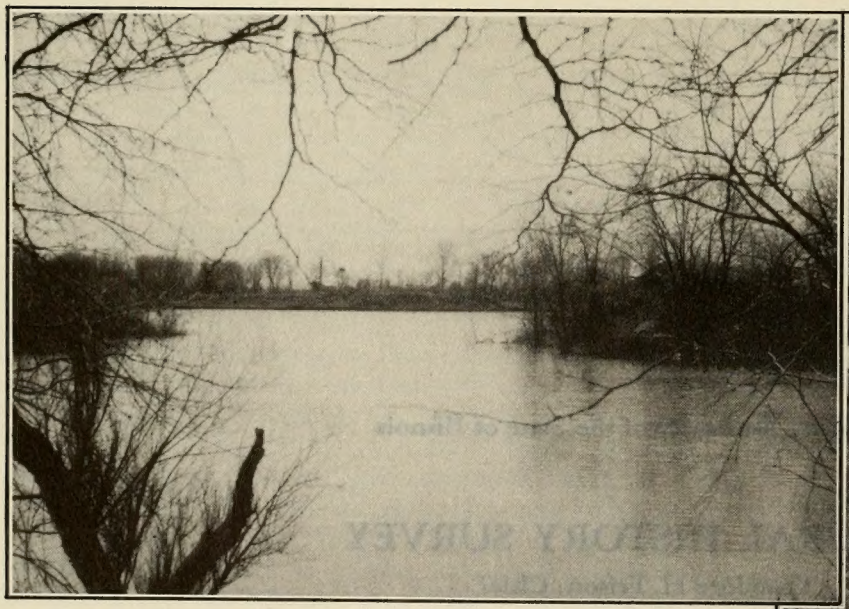

FIG. 2.--Above, a winter view of Lincoln Lakes, showing wooded shores.

FIG. 3.--Right, member of Logan County Sportsmen's Club with largemouth bass from Sportsmen's Lake, 1938.

3. LINCOLN LAKES NEAR LINCOLN, ILLINOIS

David H. Thompson and George W. Bennett
Illinois Natural History Survey

Lincoln Lakes are a series of water-filled gravel pits in the floodplain of Salt Creek, about a mile south of Lincoln, Illinois. They have been dug since 1905 by the Lincoln Sand and Gravel Company. The water area of these lakes is now about 100 acres. They are irregular in shape, and most of the wide-waters are connected by deep channels. The gravel company has developed a bathing beach, cottage sites and other recreational facilities for the general use of the community. At the present time, Lincoln Lakes constitute about one-half of the total water area of Logan County, in central Illinois, and furnish the most convenient outdoor recreational spot for the residents of Lincoln, a city of 13,000.

The water of Lincoln Lakes is clear and attractive for bathing, boating and fishing. The lakes are partially inundated at intervals of one to several years by flood water from Salt Creek. At such times the turbidity is increased, although the turbid condition remains for only a short period. As will be shown later, hook-and-line fish of sizes attractive to fishermen make up about 19 per cent of the total weight of fish in these lakes. Furthermore, an unusually large proportion of these fish are bass of large size. These fish do not take the hook readily, however, and fishing in Lincoln Lakes is considered poor.

Early in 1938, the gravel company permitted the Logan County Sportsmen's Club to use a small arm of water as an experimental area for the general improvement of the remainder of the lakes. This arm was separated from the main lakes by a levee. Most of this report deals with work carried on in this small area, which will be called Sportsmen's Lake.

ACKNOWLEDGMENTS

The Lincoln Sand and Gravel Company is interested in further developing the recreational uses of Lincoln Lakes and has given us unusually complete information. The Logan County Sportsmen's Club, and especially those members primarily interested in fishing, have given a great deal of their time and effort in carrying out the work on Sportsmen's Lake. Whatever benefits may arise from this work are to a great extent the result of their continued interest in the area. Many members have taken an active part in the work, but we should like to mention in particular Harry A. Gehlbach, Reginald Clark, Harold Klemm and Walter Spatz. A large part of the levee was built by the National Youth Administration under the direction of Herman Dammerman. At the time the census was made, we were helped by Dr. A. B. Taylor and Harry G. Kimple of the University of Illinois. Dr. Donald F. Hansen, of the Natural History Survey, helped throughout the census of Sportsmen's Lake and furnished the information on the rate of growth of the white crappies of Lincoln Lakes from his manuscript on the growth of the white crappie in Illinois. The State Department of Conservation assisted with the work previous to the census. Louis A. Krumholz, graduate assistant of the Natural History Survey, drew the maps and charts used in this report.

DESCRIPTION OF LINCOLN LAKES

Lincoln Lakes have a water area of 92.5 acres. (This does not include a new pond of about 10 acres dug since 1936.) The total shoreline is 7.3 miles. The maximum depth is reported to be 42 feet. The average depth is about 15 feet, and only 5 or 10 per cent of the water area is less than 5 feet in depth. A map of these water-filled gravel pits is shown in fig. 8. Digging has proceeded without interruption since 1905. The approximate dates of digging are shown on the map. The northwest water areas are oldest, and those of the southeast newest.

This paper is a contribution from the Section of Aquatic Biology.

The gravel which is being worked was deposited in glacial times. Four to 10 feet of topsoil must be removed to expose it. Most of the topsoil is dumped into the lakes. The first digging was done with a dragline. In 1908, this was discarded in favor of a steam dredge, which was operated until 1922, when electric equipment was installed. Digging has averaged about 3 acres a year, and future operations will extend over a period of at least 15 years. New water areas will be south of the present lakes; the company holds land as far south as Deer Creek.

The water level in the lakes is the same as that of the ground water. Surface drainage from about 500 acres of farm land to the north and east flows into the lakes. Almost every year Salt Creek overflows the low land near the dam and floods Lincoln Lakes.

The Lincoln Sand and Gravel Company has made many improvements for public recreation on the worked-over areas. A large public bathing beach, fig. 1, was constructed in 1930 and 1931 at a cost of $16,000. This figure does not include 300 carloads of sand and gravel which were used. There is a large modern bathhouse and a parking area. A small charge for swimming pays the lifeguards and other operating expenses and provides enough extra income for some new equipment each year. Figs. 2 and 3 are from photographs taken at Lincoln Lakes.

The fees for fishing and boating are as follows:

Fishing—$1.00 per year (plus the state fishing license)
Boating—A few rowboats rent at 25 cents per hour, or $1.00 per day

Privately-owned boats may be used on the lake at the following rates:

Rowboats	$ 2.00 per year
Canoes	2.00 per year
Sailboats.	3.00 per year
Motorboats	5.00 per year

Cottage sites may be leased for 10 years (renewable) at $35.00 per year. These sites have a 50-foot lake frontage and are 100 feet long. Eleven cottages are now in use.

Hunting is not allowed on this area because of the danger and the nuisance to people seeking other recreation.

A watchman-caretaker in the employ of the company handles the bait concession.

Picnicking and hiking are free--and skating when the company finds that the ice is safe.

DESCRIPTION OF SPORTSMEN'S LAKE

Sportsmen's Lake, dug in 1920 and 1921, figs. 4 and 8, is an arm of Lincoln Lakes with an area of 3.69 acres. It was diked off in 1938 in an effort to separate it from the other lakes and to prevent its being flooded by Salt Creek. The small lake is shaped somewhat like a glove with six fingers. These fingers are lined with a dense stand of small willows. The shores are wooded except on part of the west side. While the maximum depth in open water is 19½ feet, most of the channels on the east side are less than 10 feet in depth. The average depth of the entire lake is 9.8 feet; the shoreline is 0.8 mile; and the volume is 36 acre feet.

The levee built in 1938 was high enough to keep out ordinary floods on Salt Creek. However, in March, 1939, Salt Creek flooded higher than at any time since 1926, and water from Lincoln Lakes backed up into Sportsmen's Lake, covering the levee from March 13 to 16 and again for two days in April.

The Lincoln Sand and Gravel Company plans this summer to raise the levee high enough to prevent all possibility of future flooding.

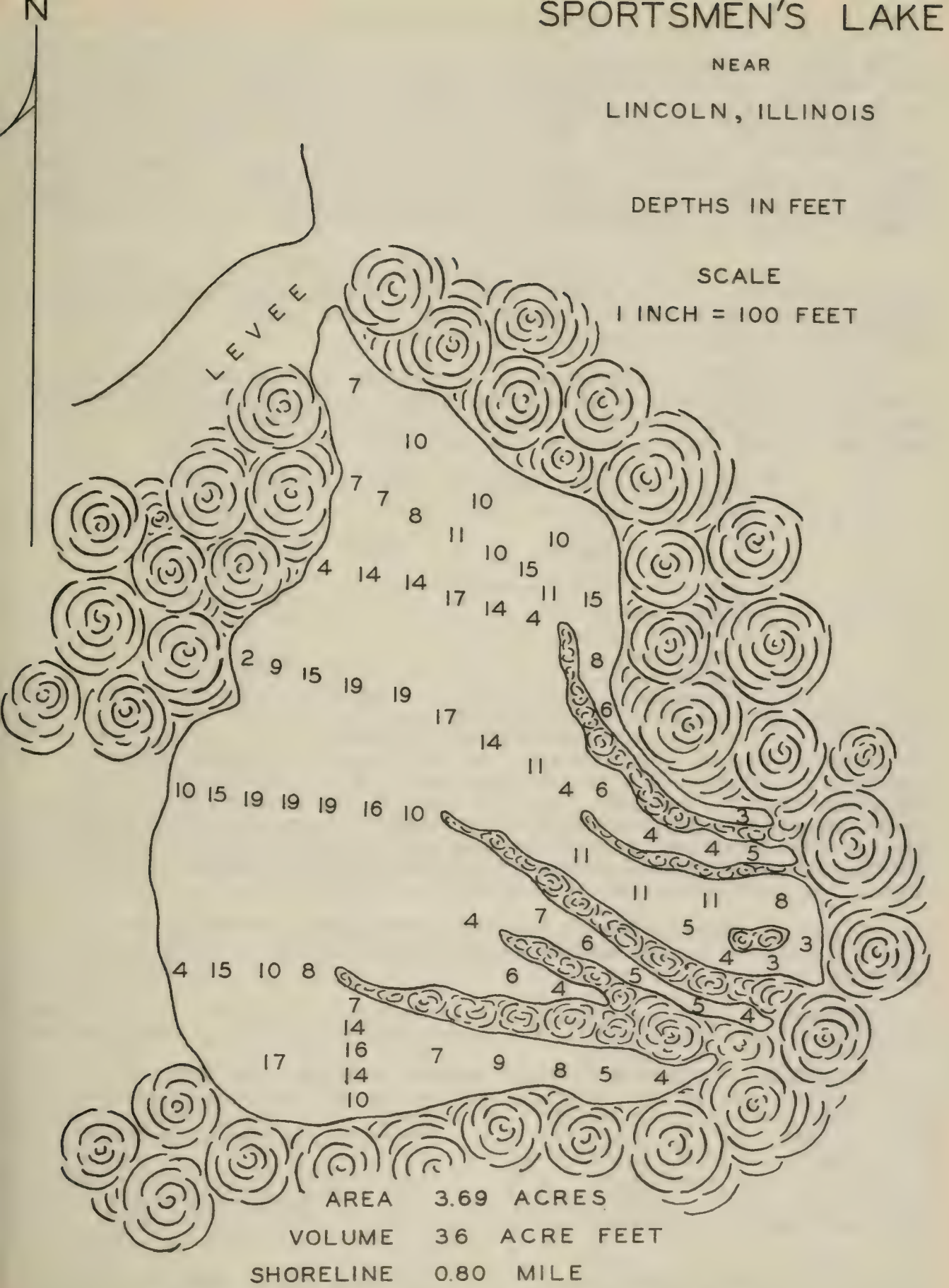

FIG. 4.—Map of Sportsmen's Lake, indicating depths in feet.

HISTORY OF FISH POPULATION

No written records have been kept of fish planted in Lincoln Lakes. The following notes have been furnished from memory by sportsmen and by officials of the gravel company. On three or four occasions since 1925, the State Department of Conservation fish car has brought fish to the lakes. These plantings included probably largemouth bass, yellow bass, white crappie, black crappie, warmouth bass, bluegill, green sunfish, yellow perch, sheepshead, channel cat, black bullhead, yellow bullhead and other Illinois River species. Trucks have brought in fish at other times. On several occasions, lake trout and wall-eyed pike fry have been planted. Fish have been stocked probably at frequent intervals since digging was begun in 1905.

Large numbers of stream fishes from Salt Creek must have entered Lincoln Lakes during times of flood. It is probable that all of the species of "rough" fish, the smallmouth bass, sheepshead, gar, gizzard shad and a number of kinds of minnows and small fishes now in Lincoln Lakes came in this way.

In July, 1937, Mr. D. John O'Donnell, at that time of the Natural History Survey, fished for two days in what is now Sportsmen's Lake with two 3½-foot, 1-inch mesh hoop nets. This place is not adapted to hoop-net fishing, and the water was too clear for some kinds to enter the nets readily. His catch is listed in table 1.

TABLE 1.--HOOP NET CATCH, JULY, 1937, SPORTSMEN'S LAKE

Kind	Number	Total Length, Inches
White crappie	7	5 to 7
Redmouth buffalo.	1	11
Yellow bass	2	4 to 5
Sheepshead.	2	7 to 8
Redhorse.	2	11
Quillback	1	7

In April, 1938, as a preliminary to the census work of the Survey, members of the Logan County Sportsmen's Club under the direction of Mr. Clifford Sullivan of the State Department of Conservation fished the pond with four hoop nets in an attempt to remove some of the fish before the water was poisoned. Several turtles were taken, but only a few fish. Nets lifted on one day, April 29, contained one slider turtle, *Pseudemys troosti* (Holbrook), and two small softshell turtles, *Amyda spinifera* (Le Sueur); only one fish was taken, a white crappie, 6.1 inches long.

No bass were taken in the nets in either 1937 or 1938. However, in both years most of the fish in the nets may have escaped through holes cut almost every night by muskrats.

Hook-and-line fishing has been poor in Lincoln Lakes. Occasional bass have been taken, but not more than one or two dozen each year. The Survey made a complete creel

TABLE 2.--AVERAGE TOTAL LENGTHS OF WHITE CRAPPIES OF DIFFERENT AGES

Date		Age in Years				
		1	2	3	4	5
June 16, 1937 (hook-and-line catch) .	Total length.	...	6.1	6.5	6.1	...
	Number of fish.	...	(1)	(5)	(27)	...
May 20, 1938 (poisoned in Sportsmen's Lake).	Total length.	4.6	5.2	5.9	6.3	6.6
	Number of fish.	(2)	(45)	(58)	(3)	(40)

census on the opening day of the 1937 bass season, June 16. Only four legal-sized fish were taken--two bass and two white crappies. Hundreds of thin white crappies under legal length (8 inches) were caught. Scales and measurements were taken from 33 of these small crappies and their ages determined by Dr. Hansen of the Survey. In table 2 the lengths and ages of these fish are compared with the lengths and ages which he found among 148 white crappies obtained when Sportsmen's Lake was poisoned.

The poor hook-and-line fishing in Lincoln Lakes is one of the reasons the Logan County Sportsmen's Club was given a small arm of the lakes to be diked off and used as a hatchery pond, rearing pond or experimental area where methods could be worked

TABLE 3.--FIRST FISH KILLED BY POISON IN SPORTSMEN'S LAKE, MAY, 1938.

Kind	Number	Total Length, Inches
Largemouth bass	9	3 to 12
Bluegill	27	1 to 6
Black crappie	1	5
White crappie	102	2 to 7½
Green sunfish	4	2½ to 5
Yellow bass	11	3½ to 6
Black bullhead	2	5 to 9
Gizzard shad	95	5 to 7
Spotted sucker	31	5 to 10
Golden shiner	20	2 to 6
Brook silverside	12	2 to 3
Darter	1	2
Miscellaneous minnows	22	1 to 3

out for the improvement of fishing in the rest of Lincoln Lakes. While the evidence indicated that fish were scarce, it was thought desirable to clean out Sportsmen's Lake with poison before any fish propagation activities were begun.

FISH PREDATORS

Animals which prey upon the fishes of Lincoln Lakes are herons, cormorants, kingfishers, gulls, fish-eating ducks, and a few turtles and gars that have migrated from Salt Creek. It does not seem likely that these predators have noticeably affected the fish population.

TABLE 4.--COMPARISON OF FIRST AND SECOND POISONINGS OF SPORTSMEN'S LAKE, MAY-JUNE, 1938.

Kind	Per Cent of Fish Escaping First Poisoning	Average Weight First Poisoning, Pounds	Average Weight Second Poisoning, Pounds
Largemouth bass	12.6	0.82	2.30
Other "fine" fish*	0.3	0.08	0.12
Bullheads	10.3	0.32	0.67
Buffaloes	15.3	1.37	2.24
Carp, quillback and suckers	0.4	0.36	1.00
Gizzard shad	None	0.07	....
Minnows and other small species	None	0.01	....

* See table 5 for a list of "fine" fish.

TABLE 5.--CENSUS OF ALL FISHES IN SPORTSMEN'S LAKE, MAY-JUNE, 1938

Kind	Number	Weight, Pounds	Average Weight Per Fish, Pounds	Per Cent of Total Weight
GAME FISH				
Largemouth bass	167	165.9	0.99	
TOTAL	167	165.9		13.2
OTHER "FINE" FISH				
White crappie	1,455	122.9	0.08	
Black crappie	4	0.6	0.15	
Warmouth bass	43	2.3	0.05	
Bluegill	1,280	85.8	0.07	
Green sunfish	145	9.3	0.06	
Orange-spotted sunfish	12	0.3	0.02	
Yellow perch	5	0.2	0.04	
Yellow bass	101	9.0	0.09	
Sheepshead	7	4.6	0.66	
TOTAL	3,052	235.0		18.7
CATFISH				
Channel cat	5	9.9	1.98	
Black bullhead	27	10.2	0.38	
Yellow bullhead	2	0.2	0.10	
TOTAL	34	20.3		1.6
"ROUGH" FISH				
Redmouth buffalo	307	467.4	1.52	
Mongrel buffalo	46	63.5	1.38	
Smallmouth buffalo	7	11.3	1.61	
Quillback	47	38.9	0.83	
Spotted sucker	184	35.2	0.19	
Common sucker	2	0.4	0.20	
Carp	10	17.1	1.71	
TOTAL	603	633.8		50.5
PREDATOR FISH				
Long-nosed gar	1	0.6	....	
TOTAL	1	0.6		....
FORAGE FISH				
Gizzard shad	2,812	190.8	0.07	
Golden shiner	75	3.1	0.04	
Bullhead minnow	83	0.3	....	
Blackfin minnow	7	.....	....	
Straw-colored minnow	31	0.1	....	
Blunt-nosed minnow	82	0.2	....	
Top minnow	4	.....	....	
Brook silverside	57	0.5	....	
Minnows and small fish not picked up	.....	5.0	....	
TOTAL	3,151	200.0		15.9

Total number of fish = 7,008
Total weight of fish = 1,256 lbs.

Number of fish per acre = 1,899
Weight of fish per acre = 340 lbs.

1938 FISH CENSUS OF SPORTSMEN'S LAKE

Sportsmen's Lake was poisoned on May 20, 1938. The open water was treated from a boat between 9:45 and 10:30 a.m. Between 10:30 a.m. and noon, a garden sprayer was used to distribute poison along the edges and in the narrow channels. The fish began to appear soon after the first poison was introduced and by noon the fish listed in table 3 had been collected, sorted and counted.

Although the poison may not have been distributed uniformly, the list in table 3 shows, in some measure, the fish that are most easily killed. The surface water temperature was 70 degrees Fahrenheit.

It required three days to handle the fish. The procedure was the same as that described in Lake Management Reports, 2. Fork Lake near Mount Zion, Illinois, published by the Natural History Survey as Biological Notes No. 9, January, 1939.

When we returned to the pond on June 2, it was reported that some fish had escaped the first poisoning. Next day we saw three fish jump. On June 14 the lake was repoisoned with twice the original dosage, 1 pound of poison per acre foot of water. This repoisoning was begun at 2 p.m., and before dark 7 largemouth bass and 20 redmouth buffalo were collected. The following day, 13 bass, 7 crappies, 3 bullheads, 1 sheepshead, 1 quillback and 35 redmouth buffalo were picked up. These fish were large and had evidently survived the first poisoning. Table 4 shows the percentage and sizes of fish escaping the first poisoning. At the time of the second poisoning, large numbers of redmouth buffalo fry and somewhat smaller numbers of largemouth bass and black bullhead fry were killed. These fry ranged between one-half and 1½ inches in length and had been spawned since the first poisoning on May 20.

TABLE 6.—FREQUENCIES OF STANDARD LENGTHS OF FISHES (EXCEPT LARGEMOUTH BASS) IN SPORTSMEN'S LAKE, MAY-JUNE, 1938.

Standard Length, Inches	Carp	Redmouth Buffalo	Mongrel Buffalo	Smallmouth Buffalo	Channel Cat	Sheepshead
7	....	2	....	....	....	....
7½	....	10	1	....	....	....
8	....	12	2	....	....	1
8½	....	11	5	....	....	1
9	....	23	3	1	....	1
9½	....	39	4	....	1	....
10	....	24	7	....	....	1
10½	....	26	....	....	....	....
11	2	11	5	1	....	....
11½	3	16	4	1	1	....
12	2	9	1	....	1	1
12½	....	6	1	....	....	....
13	....	12	2	1	....	....
13½	1	5	2	....	....	....
14	1	3	2	....	....	....
14½	....	5	....	....	....	....
15	....	4	....	....	1	....
15½	....	....	1	....	....	....
16	....	....	....	....	....	....
16½	....	1	....	....	....	....
17	....	1	....	....	....	....
17½	....	....	....	....	....	....
18	....	....	....	....	....	....
18½	....	....	....	....	....	....
19	....	....	....	....	1	....
TOTAL	9	220	40	4	5	5

(Continued on next page)

TABLE 6.—FREQUENCIES OF STANDARD LENGTHS OF FISHES (EXCEPT LARGEMOUTH BASS) IN SPORTSMEN'S LAKE, MAY-JUNE, 1938—Continued.

Standard Length, Inches	Golden Shiner	Bullhead Minnow	Blackfin Minnow	Straw-colored Minnow	Blunt-nosed Minnow
1	....	3	....	....	4
1½	....	34	1	6	41
2	....	36	6	25	32
2½	4	10	....	....	4
3	26	....	....	....	1
3½	18	....	....	....	....
4	7	....	....	....	....
4½	3	....	....	....	....
5	4	....	....	....	....
5½	1	....	....	....	....
TOTAL	63	83	7	31	82

Standard Length, Inches	Quillback	Spotted Sucker	Gizzard Shad	Black Bullhead	White Crappie	Yellow Bass
1	....	....	....	....	....	....
1½	....	....	....	....	1	....
2	....	....	1	....	5	....
2½	....	....	....	....	43	17
3	....	....	158	1	28	37
3½	....	....	342	....	8	....
4	....	8	17	....	158	4
4½	....	20	15	....	326	31
5	....	23	286	1	271	7
5½	....	22	84	....	70	4
6	....	14	180	....	46	1
6½	....	10	77	....	1	....
7	1	14	42	2	2	....
7½	1	10	31	3	1	....
8	7	16	17	9	1	....
8½	7	2	4	....	....	....
9	8	9	2	2	....	....
9½	7	2	1	....	....	....
10	9	1	1	....	....	....
10½	6	....	....	....	....	....
11	1	....	....	....	....	....
TOTAL	47	151	1,258	18	961	101

Standard Length, Inches	Bluegill	Green Sunfish	Orange-Spotted Sunfish	Warmouth Bass	Top Minnow*	Brook Silverside
1	17	2	....	....	....	....
1½	65	47	....	18	....	....
2	39	78	6	3	4	1
2½	104	8	6	6	....	25
3	71	5	....	3	....	31
3½	65	....	....	....	....	....
4	114	1	....	....	....	....
4½	82	2	....	....	....	....
5	62	1	....	....	....	....
5½	15	....	....	....	....	....
6	1	1	....	....	....	....
TOTAL	635	145	12	30	4	57

* *Zygonectes notatus* (Refinesque)

The census shown in table 5 includes the fish taken in both poisonings. A large number of individuals of all species was measured. The frequencies of standard lengths of all species (except largemouth bass) are compiled in table 6. The carp, buffalo, largemouth bass and channel cat were large. Most of the crappies, bluegills and other pan fish were small, and few of them were of legal size.

The numbers and weights of hook-and-line fishes of legal sizes are summarized in table 7. Although fishing in Lincoln Lakes is not considered good, the proportion of legal-sized hook-and-line fish is probably rather high, since they made up 19 per cent

TABLE 7.--HOOK-AND-LINE FISH OF LEGAL SIZES.

Legal Length, Inches	Kind	Number	Total Weight, Pounds
10	Largemouth bass	77	151.13
8	White crappie	8	2.79
5	Bluegill	438	57.67
5	Green sunfish	5	0.59
6	Yellow bass	12	2.59
7*	Sheepshead	7	4.60
10*	Channel cat	5	9.90
7*	Black bullhead	24	9.95
	TOTAL	576	239.38
	PER ACRE	156	64.9

* No legal lengths specified by state law. Arbitrary sizes chosen as the minimum for table use.

of the weight of all fish present in Sportsmen's Lake. It should be noted that the largemouth bass and the bluegill were the kinds which contributed most of the legal-sized fish.

AGE, GROWTH AND SEX IN THE LARGEMOUTH BASS

When Sportsmen's Lake was poisoned the first time, detailed observations were made on each individual bass. As the number was rather large and covered a wide range of sizes, we have treated these fish in some detail.

One hundred sixty-seven bass were taken in the two poisonings; 146 the first time and 21 the second (not including the newly-hatched fry). Total lengths, standard lengths and weights were taken on the first group of fish. Sex determinations were made, and scales collected for ages. Observations made on bass from the second poisoning included only the number, the total weight, 45 pounds, and the sizes of a few individual fish.

For many years fish investigators have used standard length measurements (tip of snout to end of backbone) in preference to total length measurements. Total length measurements in inches, on the other hand, are better understood by laymen and are, therefore, more useful in fish management.

Test measurements of standard lengths made by three workers on a single fish were found to vary considerably because of a difference of opinion about the exact location of the end of the backbone. On the other hand, total length measurements varied less. Total lengths are most uniform when measured from the tip of the snout, with the mouth closed, to the tip of the tail. The tail should be extended, *i.e.*, not spread. The usual objection to the use of total length is that part of the tail fin may be broken off. However, scarcely one fish in a hundred under natural conditions shows injury to the tail fin.

Standard and total lengths were compared on all measured bass taken from Sportsmen's Lake to learn whether the ratio of total length to standard length is constant. The ratio was found to change as shown in table 8. It may be seen that the body grows in length more rapidly than the tail.*

It was possible to determine the ages of all but two of the bass taken following the first poisoning. The numbers of bass of known ages are shown diagramatically by age groups in the shaded areas of fig. 5. The two bass of undetermined ages from the first poisoning and 21 bass from the second poisoning were arbitrarily assigned to age groups on the basis of size and are shown in unshaded areas in fig. 5.

Spawning and survival must have been more successful in some years than in others. As may be expected, the greatest numbers of bass were one- and two-year-olds. But, there were more fish in the five- and six-year groups than in the three- and four-year groups. This fact may indicate an abundance cycle with dominant broods appearing every three or four years. Eschmeyer** presents evidence of dominant broods among the bass

TABLE 8.--RATIO OF TOTAL LENGTHS TO STANDARD LENGTHS IN BASS OF DIFFERENT SIZES.

Standard Length, Inches	Number of Fish	Ratio of Total Length to Standard Length
2.1 to 5.0.	37	1.236
5.1 to 8.0.	49	1.226
8.1 to 11.0.	24	1.211
11.1 to 14.0.	25	1.205
14.1 to 17.0.	9	1.192

which he poisoned in Howe Lake, Michigan. In his case the first summer and fourth summer fish were much more numerous than bass of other ages.

Age determinations were made from the scales, distances between annuli were measured and the length of each fish at the end of each year of life was calculated in the usual manner. Table 9 shows the average of these calculated lengths for each year's spawn. Table 10 shows the average yearly length increases of the fish shown in table 9.

Curves showing the sum of the length increases and the average lengths of these bass are given in fig. 6. The sum of the length increases (solid line) gives, in most respects, a more nearly true picture of the growth history of these bass. Average length curves are subject to greater irregularities. For example, the nine-year old fish average slightly shorter than the eight-year old fish. This does not mean that bass shrink between their eighth and ninth years but that the eight-year old average includes two unusually large fish which are not represented in the nine-year average.

No significant differences in growth rates of the two sexes could be found.

Scales and measurements from nine largemouth bass taken by anglers from Lincoln Lakes during 1937 and 1938 show a rate of growth similar to that of the poisoned bass of Sportsmen's Lake.

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* Bennett found no change in the ratio of total to standard length in smallmouth bass when the former was measured from the tip of the snout to a line across the end of the tail spread in the natural position. Bennett, G. W. 1938. Growth of the Smallmouth Black Bass, *Micropterus dolomieu* Lacépède, in Wisconsin Waters. Copeia, No. 4, pp. 157-70.

** Eschmeyer, R. W. 1938. The Significance of Fish Population Studies in Lake Management. Trans. Third N. Am. Wildlife Conf., pp. 458-68.

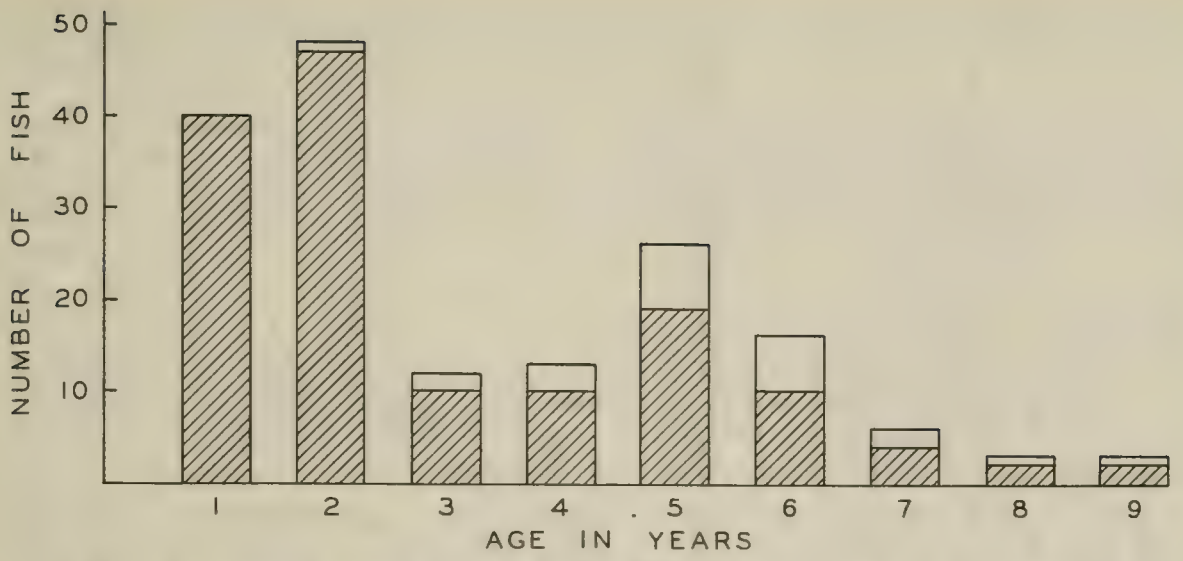

FIG. 5.--Shaded areas show numbers of largemouth bass of different ages taken from Sportsmen's Lake following first poisoning. Unshaded areas represent numbers of bass arbitrarily assigned to age groups on basis of size: 2 from first poisoning, 21 from second.

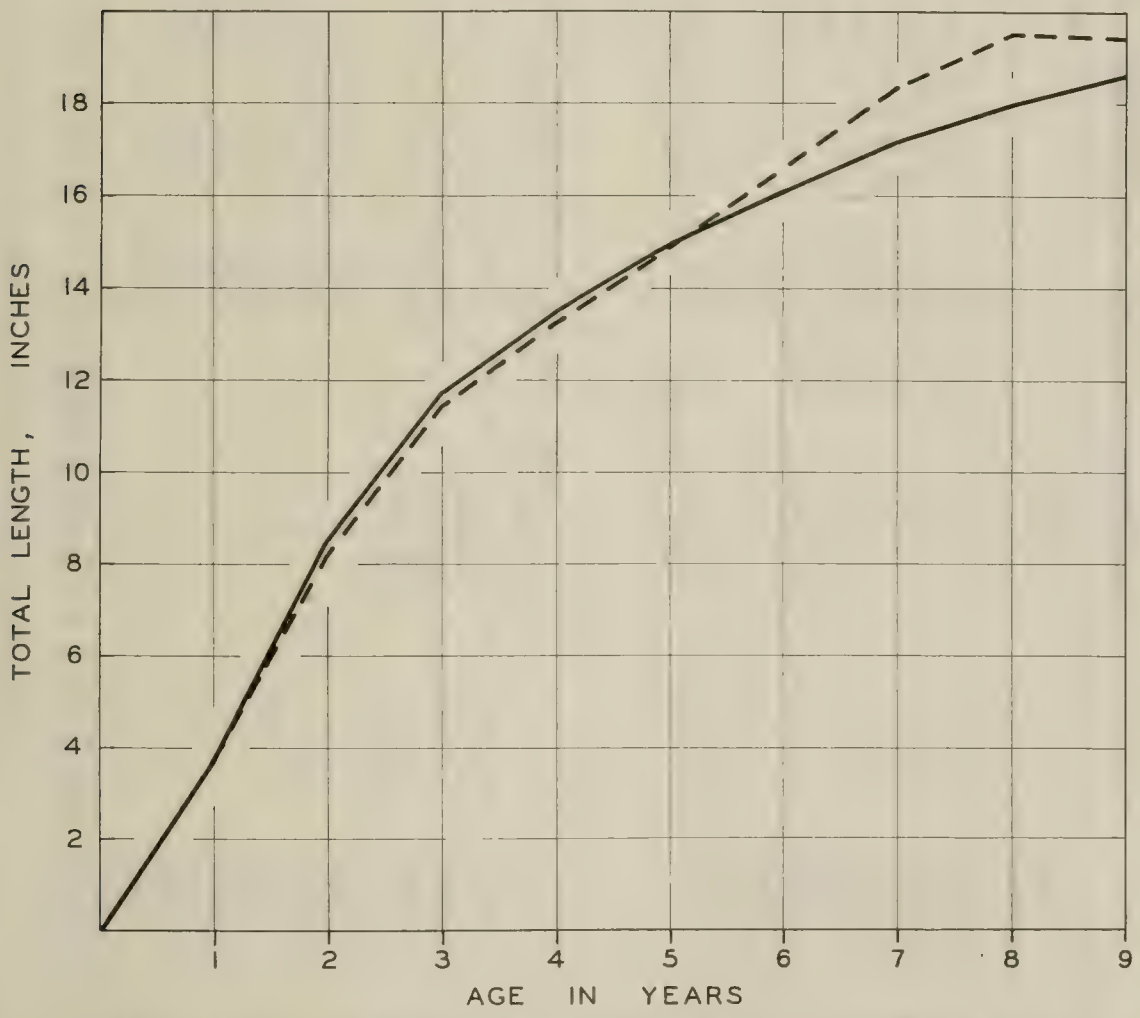

FIG. 6.--Rate of growth of largemouth bass in Sportsmen's Lake. Solid line, sum of length increases; broken line, average lengths.

TABLE 9.---CALCULATED TOTAL LENGTHS IN INCHES OF LARGEMOUTH BASS TAKEN FROM SPORTSMEN'S LAKE, MAY-JUNE, 1938.

Year Spawned	Number of Fish Averaged	Age in Years								
		1	2	3	4	5	6	7	8	9
1929	2	4.37	8.93	11.93	14.22	16.13	17.25	18.02	18.85	19.49
1930	2	3.00	8.70	13.26	15.84	17.43	18.61	19.55	20.26	.....
1931	4	2.87	7.89	12.04	14.02	15.52	16.54	17.96	.....	.....
1932	10	3.31	8.38	11.92	13.49	14.91	16.05	.....	.....	.....
1933	19	3.85	8.21	11.32	13.02	14.41	.....	.....	.....	.....
1934	10	2.74	7.58	10.80	12.41	.....	.....	.....	.....	.....
1935	10	3.31	8.05	10.98	.....	.....	.....	.....	.....	.....
1936	47	3.57	8.10	.....	.....	.....	.....	.....	.....	.....
1937	40	4.79	.....	.....	.....	.....	.....	.....	.....	.....
	144 Average	3.84	8.11	11.41	13.25	14.92	16.58	18.37	19.56	19.49

TABLE 10.---CALCULATED LENGTH INCREASES IN INCHES OF LARGEMOUTH BASS TAKEN FROM SPORTSMEN'S LAKE, MAY-JUNE, 1938.

Year Spawned	Number of Fish Averaged	Year of Life								
		1st	2nd	3rd	4th	5th	6th	7th	8th	9th
1929	2	4.37	4.56	3.00	2.29	1.91	1.12	0.77	0.83	0.64
1930	2	3.00	5.70	4.56	2.58	1.59	1.18	0.94	0.71	.....
1931	4	2.87	5.02	4.15	1.98	1.50	1.02	1.42	.....	.....
1932	10	3.31	5.07	3.54	1.57	1.42	1.14	.....	.....	.....
1933	19	3.85	4.36	3.11	1.70	1.39	.....	.....	.....	.....
1934	10	2.74	4.84	3.22	1.61	.....	.....	.....	.....	.....
1935	10	3.31	4.74	2.93	.....	.....	.....	.....	.....	.....
1936	47	3.57	4.53	.....	.....	.....	.....	.....	.....	.....
1937	40	4.79	.....	.....	.....	.....	.....	.....	.....	.....
	144 Average	3.84	4.64	3.29	1.74	1.45	1.12	1.14	0.77	0.64
	Sum of length increases	3.84	8.48	11.77	13.51	14.96	16.08	17.22	17.99	18.63

All bass of four years and older were of legal length (*i.e.*, 10 inches or more). Eight out of 10 three-year-olds were of legal length, as well as 5 of the 47 two-year-olds. The largest yearlings were 9 inches long.

Ages, length frequencies and sexual development of these 144 bass are shown in table 11. It may be seen that sexual maturity is correlated more closely with length than with age. All fish over 10½ inches long were sexually mature; all below 10 inches were immature. Examination showed that males and females become mature at about the same size.

Of the 56 sexually-mature specimens examined, 19 were females and 37 were males.

TABLE 11.--NUMBERS OF LARGEMOUTH BASS (TAKEN FROM SPORTSMEN'S LAKE, MAY-JUNE, 1938) OF DIFFERENT LENGTHS AND AGES, SEXUALLY MATURE AND IMMATURE. (SEXUAL MATURITY DETERMINED BY DISSECTION.)

Total Length, Inches	Age in Years								
	1	2	3	4	5	6	7	8	9
3½	5	..	..	..	..	..	..	..	..
4	5	..	..	..	..	..	..	..	..
4½	13	..	..	..	..	..	..	..	..
5	12	..	..	..	..	..	..	..	..
5½	3	..	..	..	..	..	..	..	..
6	..	..	..	..	..	..	..	..	..
6½	..	3	..	..	..	..	..	..	..
7	..	8	..	..	..	..	..	..	..
7½	..	9	..	..	..	..	..	..	..
8	..	10	..	..	..	..	..	..	..
8½	..	5	1	..	..	..	..	..	..
9	2	5	1	Sexually immature					
9½	..	2	..	..	..	..	..	..	..
10	..	2/1	..	..	..	..	..	..	..
10½	..	1	2/1	1	..	..	..	..	..
11	..	1	2	2	..	..	..	..	..
11½	..	..	..	1	2	Sexually mature			
12	..	..	1	2	3	..	..	..	..
12½	..	..	1	..	2	..	..	..	..
13	..	..	..	..	..	1	..	..	..
13½	..	..	..	1	..	..	..	..	..
14	..	..	1	1	2	1	..	..	..
14½	..	..	..	2	2	1	..	..	..
15	..	..	..	..	..	..	..	..	..
15½	..	..	..	..	1	..	..	..	..
16	..	..	..	..	1	1	..	..	..
16½	..	..	..	..	4	3	..	..	..
17	..	..	..	..	2	..	1	..	..
17½	..	..	..	..	..	2	1	..	..
18	..	..	..	..	..	..	..	..	..
18½	..	..	..	..	..	1	2	..	..
19	..	..	..	..	..	..	..	..	..
19½	..	..	..	..	..	..	..	..	2
20	..	..	..	..	..	..	..	1	..
20½	..	..	..	..	..	..	..	1	..
TOTAL	40	47	10	10	19	10	4	2	2

May 20 apparently bisected the time of annulus formation in the five younger age groups. Sixty of these bass had newly-formed annual rings, while 66 had not formed their 1938 rings. None of the 18 fish six or more years old had formed new rings.

These data are summarized in table 12. May 20 is about a month earlier than the mean date determined by Hansen for annulus formation in the white crappie.*

TABLE 12.--NUMBERS OF LARGEMOUTH BASS WITH AND WITHOUT NEW ANNULI ON MAY 20, 1938, SPORTSMEN'S LAKE.

Age in Years	Number With New Annulus Formed	Number Without New Annulus Formed
1	22	18
2	23	24
3	7	3
4	5	5
5	3	16
6	..	10
7	..	4
8	..	2
9	..	2
TOTAL	60	84

There is a tendency for the larger bass of an age group to form their annual ring before smaller bass of the same age. This may be seen in table 13.

Some of the bass which escaped the first poisoning in Sportsmen's Lake spawned within the next week or two; large numbers of inch-long fry were killed by the second poisoning, June 14. This seems to indicate a close correlation between the time of annual ring formation and the time of spawning.

TABLE 13.--NUMBERS OF BASS OF DIFFERENT LENGTHS WITH AND WITHOUT NEWLY-FORMED ANNULI, MAY 20, 1938, SPORTSMEN'S LAKE.

Standard Length, Inches	One-Year Old Bass		Two-Year Old Bass	
	Ring Formed	Ring Not Formed	Ring Formed	Ring Not Formed
2	....	....	....	....
2½	....	1	....	....
3	2	3	....	....
3½	....	....	....	....
4	13	2	....	....
4½	....	3	....	....
5	....	....	....	1
5½	....	....	1	5
6	....	....	2	11
6½	....	....	5	5
7	....	....	6	1
7½	2	....	3	....
8	....	....	3	1
8½	....	....	2	....
9	....	....	1	....
TOTAL	22	18	23	24
AV. LENGTH	4.1	3.6	7.2	6.1

Fish are often described as plump or thin, but investigators have devised a more accurate method of measuring condition by dividing the weight of the fish by the cube

* Hansen, Donald F., 1937. The Date of Annual Ring Formation in the Scales of the Whi Crappie. Trans. Am. Fish. Soc., 66:227-36.

of its length. It is most convenient to divide the weight in pounds by the cube of the total length in inches. In order to avoid long decimals, the result is multiplied by 10,000; in other words, the decimal point is moved four places to the right. For example, a 10-inch fish weighing one-half pound will have an index of condition of $\frac{0.5 \text{ lb.} \times 10{,}000}{10 \text{ in.} \times 10 \text{ in.} \times 10 \text{ in.}}$, or 5.0. A 20-inch fish weighing 4 pounds will have an index of condition of $\frac{4 \text{ lbs.} \times 10{,}000}{20 \text{ in.} \times 20 \text{ in.} \times 20 \text{ in.}}$, or 5.0. Thus it may be seen that they are equally plump. This figure can be referred to as the index of condition, or abbreviated as C.

Other workers have devised similar methods for comparing the plumpness of fish of different sizes, but most of them have used lengths in centimeters and weights in grams; or have used standard lengths, or some linear measurement other than total length. One of the most common measures is calculated from standard lengths in millimeters and weights in grams. This is called the coefficient of condition, or K. This is troublesome to the average fisherman because he usually measures fish in inches and weighs them in pounds.

The index of condition, C, was calculated for each of the bass taken from Sportsmen's Lake which were weighed and measured. Table 14 shows that C becomes progressively greater in longer fish. This indicates that large bass are stockier than small bass.

TABLE 14.--AVERAGE INDEX OF CONDITION, C, OF LARGEMOUTH BASS OF DIFFERENT SIZES, SPORTSMEN'S LAKE, MAY 20, 1938.

Total Length, Inches	Number of Fish	Index of Condition, C
3.1 - 6.0	11	4.05
6.1 - 9.0	19	4.22
9.1 - 12.0	16	5.78
12.1 - 15.0	10	5.16
15.1 - 18.0	8	5.53
18.1 - 21.0	6	6.08

It may be interesting in later work to use this bass population for comparison with the bass populations of other waters. The relation of standard length to total length has been smoothed of its minor irregularities by fitting a curve. In like manner the relation between length and weight has been smoothed. Table 15 shows corresponding lengths, weights and values of C and K, read or computed from these smoothed curves.

TABLE 15.--CORRESPONDING LENGTHS, WEIGHTS, INDICES OF CONDITION (C) AND COEFFICIENTS OF CONDITION (K) OF LARGEMOUTH BASS FROM SPORTSMEN'S LAKE, MAY 20, 1938.

Total Length, Inches	Standard Length, Inches	Weight, Pounds	C	K	Total Length, Inches	Standard Length, Inches	Weight, Pounds	C	K
4	3.24	0.03	3.93	2.07	13	10.73	1.09	4.98	2.44
5	4.05	0.05	4.02	2.11	14	11.58	1.40	5.11	2.49
6	4.87	0.09	4.14	2.14	15	12.45	1.78	5.26	2.55
7	5.70	0.15	4.24	2.18	16	13.31	2.22	5.42	2.60
8	6.53	0.22	4.35	2.22	17	14.18	2.74	5.58	2.66
9	7.36	0.33	4.46	2.26	18	15.01	3.32	5.73	2.72
10	8.21	0.46	4.60	2.31	19	15.89	4.03	5.88	2.78
11	9.03	0.63	4.73	2.35	20	16.78	4.85	6.06	2.85
12	9.88	0.84	4.85	2.40	21	17.66	5.78	6.24	2.91

LIMNOLOGICAL OBSERVATIONS

On June 2, 1938, temperatures were taken at two stations in the deeper water (Stations A and B) and at the head of one of the larger fingers (Station C) of Sportsmen's Lake. These temperatures are shown in table 16.

TABLE 16.--TEMPERATURES IN DEGREES FAHRENHEIT IN SPORTSMEN'S LAKE, JUNE 2, 1938.

Depth, Feet	Station A Temperature	Station B Temperature	Station C Temperature
0	78.25	.....	76.0
1	.....	.....	.....
2	78.0	.....	.....
3	.....	.....	.....
4	77.5	.....	.....
5	.....	.....	75.0
6	76.0	.....	.....
7	74.0	.....	.....
8	68.0	70.5	71.0, bottom
9	67.0	.....	
10	63.0	64.2	
11	.....	.....	
12	59.5, bottom	57.7	
13		.....	
14		54.0	
15		.....	
16		51.0	
17		.....	
18		49.0	
19		.....	
19½		47.3, bottom	

Later in the summer, on August 12, temperatures and oxygen samples were taken at one station in the deep, open water of Lincoln Lakes, as well as in Sportsmen's Lake. The first location was about 200 feet west of the boatyard. The station in Sportsmen's Lake was the same as Station B on June 2. The temperatures and dissolved oxygen concentrations found are shown in table 17.

TABLE 17.--TEMPERATURES IN DEGREES FAHRENHEIT AND DISSOLVED OXYGEN CONCENTRATIONS IN PARTS PER MILLION IN SPORTSMEN'S LAKE AND OTHER PARTS OF LINCOLN LAKES, AUGUST 12, 1938.

Depth, Feet	Lincoln Lakes		Sportsmen's Lake	
	Temperature	Dissolved Oxygen	Temperature	Dissolved Oxygen
0	87.0	...	....	...
1	87.0	9.1	87.8	7.9
2	....	...	....	...
3	86.3	...	86.5	...
4	....	...	....	...
5	85.0	...	85.0	7.3
6	....	...	....	...
7	84.0	...	84.3	...
8	....	...	....	...
9	83.2	...	83.5	...
10	....	...	....	7.6
11	82.4	...	80.2	...

(Continued on next page)

TABLE 17.--TEMPERATURES IN DEGREES FAHRENHEIT AND DISSOLVED OXYGEN CONCENTRATIONS IN PARTS PER MILLION IN SPORTSMEN'S LAKE AND OTHER PARTS OF LINCOLN LAKES, AUGUST 12, 1938--Continued.

Depth, Feet	Lincoln Lakes		Sportsmen's Lake	
	Temperature	Dissolved Oxygen	Temperature	Dissolved Oxygen
12	....	...	....	...
13	80.0	...	76.0	8.8
14	....	...	....	...
15	76.0	...	70.2	...
16	....	...	....	1.4
17	70.0	...	66.7	...
18	....	...	....	...
19	65.0	0.5	58.5	0.0, bottom
20	....	...		
21	61.0	0.0		
22	....	...		
23	59.0	...		
24	....	...		
25	58.0	...		
26	....	...		
27	56.6	...		
28	....	...		
29	55.7	0.0, bottom		

The two series of temperatures taken in Sportsmen's Lake, June 2 and August 12, are diagramed in fig. 7.

The common kinds of fish found in artificial lakes in Illinois--largemouth bass, white crappie, black crappie and bluegills--require two to three parts per million

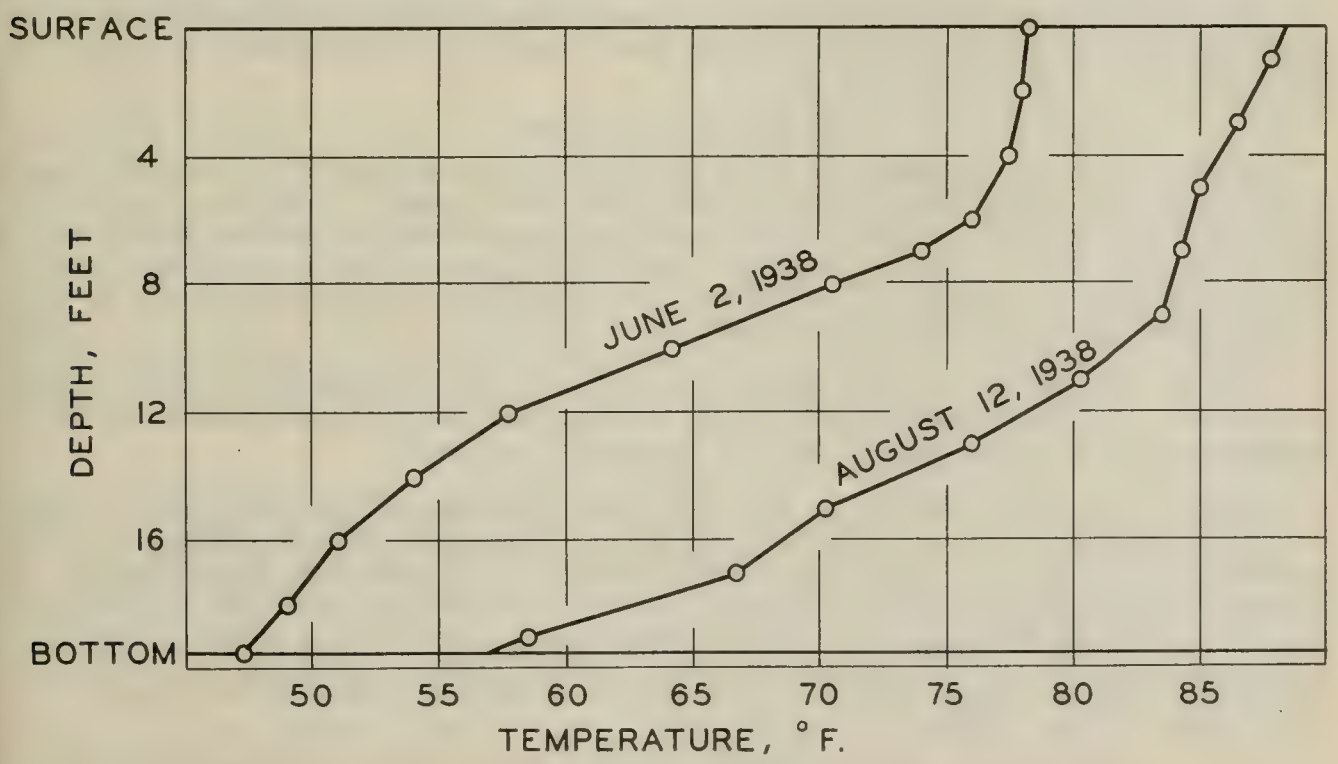

FIG. 7.--Water temperatures in Sportsmen's Lake, June 2 and August 12, 1938.

of dissolved oxygen. In Lincoln Lakes, in summer, they cannot be expected to live below a depth of 15 feet. Bullheads, however, do not require such a high concentration of oxygen as the other kinds of fish of Lincoln Lakes. Both the black bullhead and the yellow bullhead can tolerate an oxygen concentration as low as one-half part per million.

TABLE 18.--CHEMICAL ANALYSES OF WATER FROM SPORTSMEN'S LAKE.

Determination	April 30, 1938, Parts Per Million	Nov. 16, 1938, Parts Per Million
Iron		
filtered	0.08	trace
unfiltered	0.1	0.2
Silica (SiO_4)	4.0	1.5
Calcium (Ca)	49.5	37.1
Magnesium (Mg)	23.5	24.2
Potassium (K)	0.9	4.4
Sulfate (SO_4)	42.1	34.8
Nitrate (NO_3)	3.2	1.7
Chloride (Cl)	3.0	4.0
Methyl orange alkalinity	172.0	156.0
Total hardness	220.5	192.0

The transparency of Sportsmen's Lake on the day it was first poisoned (May 20, 1938) was 3 feet, as measured by a Secchi disc. Later, on June 2, after the silt roiled by the fish had settled, the transparency was 9 feet. A heavy crop of plankton algae had reduced the transparency on August 12 to 4 feet 3 inches. On November 16 it was again 3 feet.

Lincoln Lakes on August 12 showed a transparency of 3 feet 9 inches.

Chemical analyses were made by Mr. J. B. Swartz of the State Water Survey on samples of water collected from Sportsmen's Lake on April 30 and November 16, 1938. These analyses are shown in table 18.

COARSE AQUATIC PLANTS

Lincoln Lakes support very few submerged, coarse aquatic plants. At various times in the past, attempts have been made to establish several kinds. Some years ago the curly-leaved potamogeton *(Potamogeton crispus)* was planted near the bathing beach. It spread over the beach so rapidly that it became objectionable to bathers and was pulled up. At present very little of this plant is left, and it has not caused trouble on the bathing beach since its peak of abundance.

At the time Sportsmen's Lake was poisoned (May 20) it contained only a very sparse, short growth of *Potamogeton foliosus* in one of the larger necks of water where the transparency was somewhat greater than in the rest of the pond.

On May 26-28, 1938, members of the Logan County Sportsmen's Club collected a truckload of aquatic vegetation from some old strip mine ponds near Oakwood, Illinois, and planted it in Sportsmen's Lake. This load consisted of *Ceratophyllum, Myriophyllum, Ranunculus, Chara* and several species of *Potamogeton* (including *P. foliosus*). Plantings were made along the shores and in the narrow necks. An inspection on August 12 showed that *P. foliosus* had "taken" the pond. It was abundant in all the necks and along the shores, growing in as much as 5 feet of water. A few thrifty plants of *Ceratophyllum* were present near the levee.

On November 16, the *Potamogeton foliosus* had entirely disappeared, but some other forms were growing more or less abundantly. Collections made in shallow water near the

levee at the north end of the lake included *Ranunculus, Chara, Myriophyllum* and *Ceratophyllum.* These latter kinds evidently came from the truckload planted in May.

RESTOCKING WITH LARGEMOUTH BASS AND BLUEGILLS

Plans for restocking were discussed with members of the Sportsmen's Club, and it was decided to use largemouth bass and bluegills in order to test this combination further for high production of hook-and-line fish. (See Lake Management Reports, 2. Fork Lake near Mount Zion, Illinois, referred to previously). Plantings have been made from a number of sources and at various times since the second poisoning on June 14. These are listed in table 19.

TABLE 19.--DATA ON RESTOCKING OF SPORTSMEN'S LAKE.

Date	Large-mouth Bass	Blue-gills	Size Range, Inches	Source	Donor
1938					
June 22 . . .	...	36	3-6	Homewood Lake. . .	Dept. Conservation
June 24 . . .	...	30	3-6	Homewood Lake. . .	Dept. Conservation
Aug. 18 . . .	5	...	6-10	Senachwine Lake. .	Nat. Hist. Survey
	103	...	3-5	Senachwine Lake. .	Nat. Hist. Survey
Oct. 22 . . .	14	...	8-12	Chautauqua Lake. .	Dept. Conservation
	...	93	4-6	Chautauqua Lake. .	Dept. Conservation
Nov. 16 . . .	7	...	5-7	Missouri	U. S. Bur. Fish.
	28	...	2-4	Missouri	U. S. Bur. Fish.
Dec. 31 . . .	37	...	6-11	Chautauqua Lake. .	Dept. Conservation
	...	96	4-7	Chautauqua Lake. .	Dept. Conservation
1939					
Jan. 4 . . .	33	...	6-11	Chautauqua Lake. .	Dept. Conservation
TOTAL	227	255			

When planted, all of the bluegills were large enough to spawn. Approximately 20 per cent of the bass will be of spawning size in 1939. Occasional fly-fishing in the early fall of 1938 showed that the bass planted on August 18 were growing rapidly.

Although the Sportsmen's Lake levee was topped by the flood of March, 1939, we believe that, because the water was cold, there was little or no movement of fishes between the small experimental lake and the rest of Lincoln Lakes. During this flood there was ice along the shores, and on the afternoon of the first day the water temperature was 34 degrees Fahrenheit.

On the second flood, a month later, which is reported to have connected Sportsmen's Lake with the rest of Lincoln Lakes on April 16-17, we do not have such detailed information as on the first. We know that the air temperature of the Lincoln weather station at this time was somewhat above freezing, but the probability is that the water temperature at that time was not high enough to encourage fish movement.

We are supporting the belief that there was not much fish movement in either of these floods by our experience at Horseshoe Lake when it was flooded for a much longer period in January and February, 1937.* Observers reported that at the time of the Salt Creek floods of 1939 there was no current through Sportsmen's Lake to encourage the movement of fishes.

The number of bass stocked in Sportsmen's Lake is greater than the number poisoned and will be augmented by the 1939 spawn. Unless there was more fish movement during the

* Thompson, David H., and George W. Bennett. Lake Management Reports. 1. Horseshoe Lake near Cairo, Illinois. Illinois Natural History Survey Biological Notes No. 8. September, 1938.

1939 floods than we suspect, the bass planted in Sportsmen's Lake will be free from competition by crappies and other carnivorous species now in Lincoln Lakes. Bluegills offer little competition to bass and should produce an abundance of young for bass food. Considerable numbers of young bluegills may be expected to survive the summer of 1939 and grow too large for bass to eat.

RECOMMENDATIONS FOR SPORTSMEN'S LAKE

The bass and bluegills of Sportsmen's Lake should be fished heavily during 1939 as well as in subsequent years. It is advisable to remove 100 or more of these bass during 1939. Any bass below legal length taken on hook and line should be carried across the levee and placed in Lincoln Lakes. In like manner it is recommended that 150 or more of the breeder bluegills be removed.

There should be no further stocking of the pond.

Minnows should not be used for bait because of danger of contamination of the pond with undesirable kinds. Artificial baits, worms, grasshoppers, crayfishes, etc., are suggested.

It is especially urged that the members of the Sportsmen's Club keep a complete record of the numbers and weights of fish taken from Sportsmen's Lake. These should be recorded in a bound record book along with notes on transparency of the water, submerged vegetation, waterfowl, fish predators, dead fish, etc. The equipment for making these observations and the record book should be kept in a locked box set up near the levee. A supply of scale envelopes should be included for the collection of scales and measurements useful in following the growth of the fish. A gage board should be attached to a substantial post or piling near the box. Keys to the box should be carried by those members of the club most interested in fishing. A rough table nearby would be a convenient place to clean fish and to make observations on them.

The levee should be built higher than any possible floods on Salt Creek. The installation of a frame with rollers would provide a convenient method for transferring light boats back and forth between Sportsmen's Lake and other parts of Lincoln Lakes. The levee should be planted with *Lespedeza* or other low, soil-binding plants which prevent erosion. No further erosion control or planting seems necessary around Sportsmen's Lake. No further aquatic plantings seem necessary until the results of last year's planting are learned.

RECOMMENDATIONS FOR LINCOLN LAKES

Since the water supply of Lincoln Lakes is ground water, except for surface drainage from about 500 acres of farm land and overflow from floods on Salt Creek, it seems advisable to build levees to keep out flood waters from the creek, as these waters make the lake turbid and bring in undesirable fish. It is probable that the high fish production in Lincoln Lakes may be maintained through drainage from the surrounding farm land.

If larger amounts of submerged aquatic vegetation seem desirable, they may be transplanted from Sportsmen's Lake after they have been tested there.

Much better bass fishing than in recent years seems possible, and more successful methods for taking these bass on hook and line should be sought. Since Lincoln Lakes are unusually deep and relatively free of organic matter, satisfactory amounts of oxygen are present in midsummer at depths as great as 15 feet. This condition suggests that the bass may spend most of their time in deep water. Lincoln Lakes are crowded with large numbers of small, stunted white crappies. White crappies of legal size should be removed as rapidly as possible in order to promote more rapid growth among those remaining and to reduce their competition with the bass.

A few dozen nest boxes erected at suitable places around Lincoln Lakes may promote the establishment of wood ducks in the area.

SUMMARY

1. Lincoln Lakes are water-filled excavations made by the Lincoln Sand and Gravel Company since 1905. This company has developed these water areas in many ways for public recreation.

2. These lakes now have a water area of about 100 acres, about half of the total water area of Logan County.

3. The company, in 1938, turned over a small area of water to the Logan County Sportsmen's Club to be used for the improvement of fishing in Lincoln Lakes. This area has been separated from the other lakes by a levee and is called Sportsmen's Lake.

4. After unsuccessful attempts to remove the fish of Sportsmen's Lake with nets, it was poisoned on May 20, 1938. A few large buffalo, bullheads and bass survived this first poisoning, and it was repoisoned on June 14; twice the original dosage was used.

5. A complete fish census was made which included at least 29 species. A total of 7,008 fish weighed 1,256 pounds, the per acre equivalent of 1,899 fish weighing 340 pounds. About 19 per cent of the total, or 239.4 pounds, were hook-and-line fish of legal or edible sizes.

6. The white crappies of Lincoln Lakes, although numerous, are small; age determinations showed that they have grown very slowly.

7. A comparison of standard and total lengths on 146 largemouth bass showed that the body of the fish grows in length more rapidly than the tail.

8. The growth histories of these bass were read from their scales and their lengths calculated for each year of life. All bass four years of age and older were of legal length. Eight out of 10 three-year-olds were of legal length, as well as 5 of 47 two-year-olds.

9. Evidence was found that dominant broods of bass occur at intervals of three or four years. It appears that bass between one and seven years of age die at the rate of about 25 per cent per year, while older bass die at the rate of about 50 per cent per year.

10. Sexual maturity in bass was found to be related more closely to size than to age. Both males and females become sexually mature when they reach total lengths of 10 to 10½ inches, regardless of age.

11. About one-half of all the bass under five years of age had, on May 20, 1938, new annual rings on their scales. None of the older fish had 1938 rings. There is a tendency for the large fish of an age group to form annual rings before the smaller fish of the same age.

12. A method was devised for measuring condition, or plumpness, by use of total length in inches and weight in pounds.

13. Transparencies, temperatures and chemical characteristics of the water for 1938 were determined.

14. Indigenous, coarse aquatic plants increased after the fish were poisoned and the water had cleared. Other kinds were planted with some success.

15. Sportsmen's Lake was restocked with largemouth bass and bluegills.

16. Suggestions for the improvement and management of Sportsmen's Lake and Lincoln Lakes during the next few years were outlined.

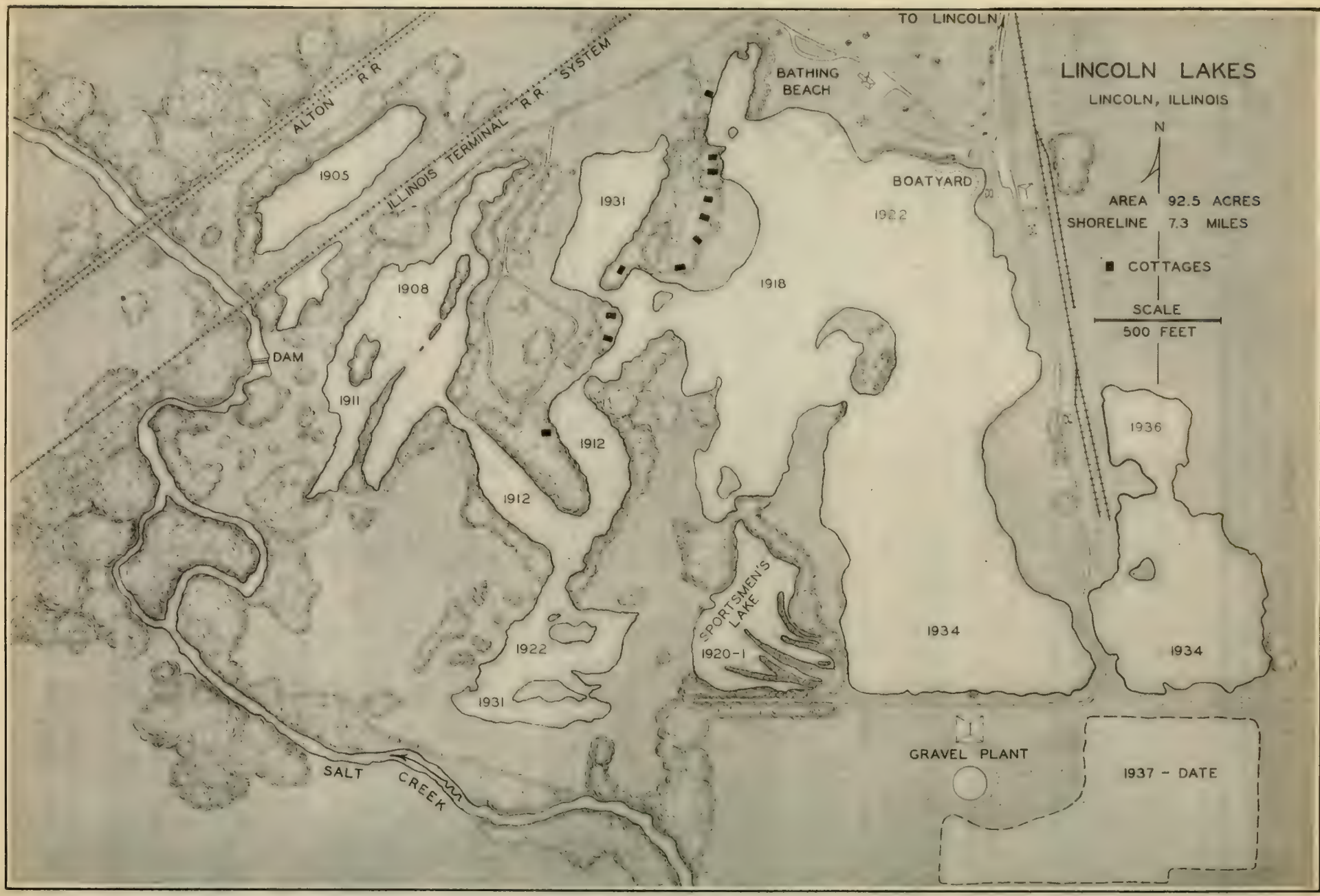

FIG. 8.--Map of Lincoln Lakes, showing the approximate dates on which the lakes were dug.